Improvements in or relating to the manufacture of axle shafts

Publication number:	GB766115	
Publication date:	1957-01-16	
Inventor:		
Applicant:	EATON AXLES LTD	
Classification:		
- international:	***B21K1/06; C21D9/28;*** **B21K1/06; C21D9/28;**	
- european:	B21K1/06; C21D9/28	
Application number:	GB19550009393 19550331	
Priority number(s):	USX766115 19540413	

Also published as:

FR1122554 (A)

Abstract of **GB766115**

766,115. Making shafts. EATON AXLES, Ltd. March 31, 1955 [April 13, 1954], No. 9393/55. Class 83 (2). A method of manufacturing shafts comprises the consecutive steps of forging an asrolled bar to basic shaft shape, next quenching the heated forged shaft and tempering it to predetermined core hardness, then machining the shaft to substantially finished form and size, induction hardening the shaft to predetermined surface hardness, and then quenching and tempering the shaft to draw back the surface hardness to a predetermined amount. An as-rolled alloy steel bar is forged to shape 10 with an annular flange 16 at one end and an enlarged cylindrical portion 18 at the other end. The form 10 is then quenched in oil, after heating to 1500-1550 F., until the form reaches a temperature of 325-350 F. when the form is removed and tempered all over at 1100-1200 F. for 1 hours to a core hardness of 275-321 Brinell. The form 10 is then, if necessary, straightened, cut off and centred. The flange 16 is then machined to shape, Fig. 3, and the portion 18 machined to provide splines 22. Defects are removed by belt grinding the shaft. The shaft is then induction hardened to provide a surface hardness of 59-64 Rockwell C and, immediately after, oil-quenched and tempered at 400-600 F. to a surface hardness of 52-57 Rockwell C. A final straightening and shot peening is then effected if necessary and a final machining to provide, for example, shaft puller holes 24 is also effected.

FIG. 2.

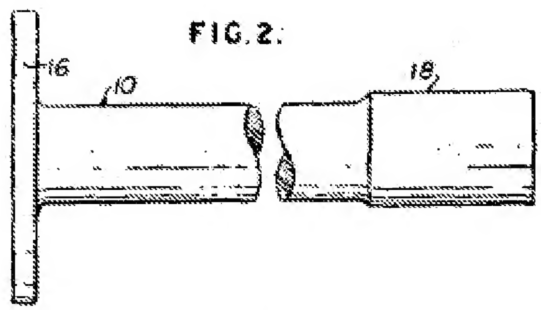
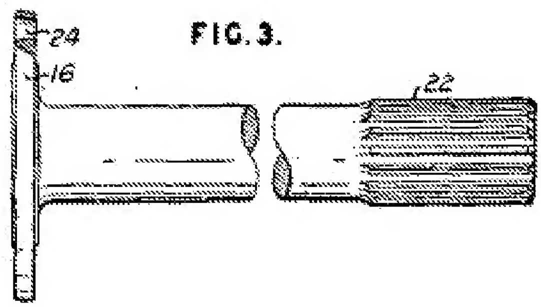


FIG. 3.



PATENT SPECIFICATION

766,115

Date of Application and Filing Complete Specification: March 31, 1955. *No. 9393/55*

Application made in United States of America on April 13, 1954.

Complete Specification Published: Jan. 16, 1957.

Index at Acceptance:—Class 83(2), A147.

International Classification:—B23p.

COMPLETE SPECIFICATION

Improvements in or relating to the Manufacture of Axle Shafts.

We, EATON AXLES LIMITED, a British Company, of Victoria Road, Great Sankey, Warrington, Lancashire, do hereby declare this invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to the method of manufacture of shafts. Broadly, the invention relates to the method of manufacturing shafts, such as axle shafts, intended for transmitting high torque loads. By employing the method of manufacture herein disclosed it has become possible to produce axle shafts having superior torsional properties to those produced by known methods. One of the basic steps employed in the present method is the induction hardening of the shafts at a suitable stage of the process.

Among the several objects of the invention is the provision of a method for the manufacture of axle shafts, or shafts adaptable for similar use, that;

a. Provides shafts possessing high mechanical properties in torsion in combination with high fatigue resistance;

b. Insures consistently obtaining the properties set forth in (*a*);

c. Insures reproducibility of a specific hardness gradient from the surface to the centre of the shafts;

d. Provides shafts virtually free from the danger of developing cracks in the spline and flange fillets of the shafts when quenching for hardness;

e. Provides for the development of a high state of compressive stress in the outer section of the shafts as compared to previously manufactured shafts of a like nature;

f. Permits a depth control of the annular high hardness zone of said shafts; and

g. Permits of a basic machining of the shaft prior to the high surface hardening thereof.

The application of the method of the present invention is hereinafter described with reference to the accompanying drawings, in which:

Fig. 1 is a top elevation partly broken away view of an as-rolled bar used in the manufacture of axle shafts;

Fig. 2 is a top elevation partly broken away view of an axle shaft subsequent to the initial forging operation thereon; and

Fig. 3 is a top elevation, partly broken away view of a complete axle shaft.

It has been determined by the process of manufacture expounded hereby that superior axle shafts, or the like, can be produced as compared to like axle shafts produced heretofore by other methods. As taught herein it is basically important that certain prescribed steps of manufacture be followed to produce certain desired results. These fundamental steps in the order of successive operation are: (1) forging of the shaft from an as-rolled bar to the desired shape; (2) quenching the heated forging and tempering it all over to develop a desired core hardness; (3) machining the axle shaft; (4) induction hardening the shaft to a prescribed surface hardness; (5) tempering the shaft to a final desired surface hardness; and (6) finish-machining as necessary. In addition to the production of a shaft of desirable properties, through the use of the aforesaid method, the necessity of costly machining operations after final hardening, as heretofore practised, is eliminated.

The process as herein taught comprises the initial step in the forging of an axle shaft to a basic form or shape 10 from an as-rolled relatively soft bar 12. The axle shaft as it assumes the form 10 includes a major cylindrical body portion 14, an annular flange 16 at one axial extremity integral with portion 14 and an enlarged cylindrical portion 18 at the opposite axial extremity thereof integral with portion 14. Subsequent to the initial forging step the form 10 is quenched and tempered all over to develop a core hardness of between 275 and 321 Brinell. The quenching is carried on in oil after heating to 1500° to

1550°F., the quenching being continued until the form 10 reaches a temperature of between 325° and 350°F., to thus prevent cracking, whereupon the form 10 is removed from the quench bath. The tempering step is then carried out for approximately 1½ hours at a temperature ranging between 1100° and 1200°F. Next, as necessary, form 10 is straightened, cut off and centered. Flange 16 is then machined to the shape shown by Fig. 3 as forming a completed part of the final form axle shaft 20, and the portion 18 is machined to provide the spline 22 shown by Fig. 3. At this stage of operation it is preferable to remove steel defects by belt grinding the surface of the shaft. The shaft 20 is next subjected to an induction hardening operation upon the flange fillet, body and splines, such as by the well known Tocco (Registered Trade Mark) induction hardening process, to provide a surface hardness thereof of between 59 and 64 Rockwell C. An immediate oil quenching thereof follows and subsequently the shaft is tempered all over at 400° to 600°F. to draw the shaft to a surface hardness of between 52 and 57 Rockwell C. A final straightening operation is then carried out if necessary. The shaft may then, if desired, be shot peened to lend additional fatigue strength but this is not essentially or generally necessary. A final machining of the shaft is next performed, such as a finish machining of shaft puller holes 24.

In so accomplishing virtually all the machining necessary on the shaft when the shaft is in form 10 having a Brinell hardness of between 275 and 321 a material tool cost saving is possible as compared to prior methods of manufacture comparable hereto wherein the flange and splined sections of the shaft are formed at a higher hardness level in the neighbourhood of between 363 and 444 Brinell, which hardness is virtually at the end of the commercial machinability range. Furthermore, in instances where it is impractical to machine the shaft in the end range of machinability, the present process eliminates the operation of tempering back the flange, to so provide for its practical machining. Additionally it is advantageous in that through the grinding of the shaft for steel defects when the shaft is in a reasonably soft state a longer grinding belt life is possible. Furthermore, through the method taught hereby for the manufacture of axle shafts, it is deemed possible to eliminate the use of high nickel content steels, now employed, and substitute a more economical and/or more readily obtainable alloy steel in place thereof.

What we claim is:—

1. A method of manufacturing shafts comprising the consecutive steps of: forging an as-rolled bar to basic shaft shape, next quenching the heated forged shaft and tempering it to predetermined desired core hardness, then machining the shaft to substantially finished form and size, induction hardening the shaft to predetermined desired surface hardness, and then quenching and tempering the shaft to draw back the surface hardness to a predetermined desired amount.

2. A method of manufacturing shafts according to Claim 1, wherein the induction hardening of the shaft provides a surface hardness in excess of the core hardness produced by the initial quenching and tempering step, and wherein the final quenching and tempering step provides for a surface hardness of the shaft of an amount less than that produced by the induction hardening step and an amount greater than that produced by the initial quenching and tempering step.

3. A method of manufacturing shafts according to Claim 2, wherein the initial quenching and tempering step produces a core hardness of between 275 and 321 Brinell, the induction hardening step produces a surface hardness of between 59 and 64 Rockwell C and the final quenching and tempering step produces a surface hardness of between 52 and 57 Rockwell C.

4. A method of manufacturing shafts according to Claims 1, 2, or 3, wherein the first quenching of the shaft is carried out in oil after heating to a temperature of between 1500° and 1550°F., the first tempering of the shaft is carried out for approximately 1½ hours at between 1100° and 1200°F., and wherein the final tempering of the shaft is carried out at between 400° and 600° F.

5. A method of manufacturing shafts according to any preceding claim including the step of belt grinding the shaft surface after the machining operation and before the induction hardening of the shaft.

6. A method of manufacturing axle shafts arranged and operated substantially as herein described with reference to the companying drawings.

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Printed for Her Majesty's Stationery Office by Kingston Printers Ltd., Portsmouth. 335/3.—1956.
Published at The Patent Office, 25, Southampton Buildings, London, W.C.2, from which copies may be obtained.

766,115 COMPLETE SPECIFICATION
1 SHEET
This drawing is a reproduction of the Original on a reduced scale.

Fig. 1.

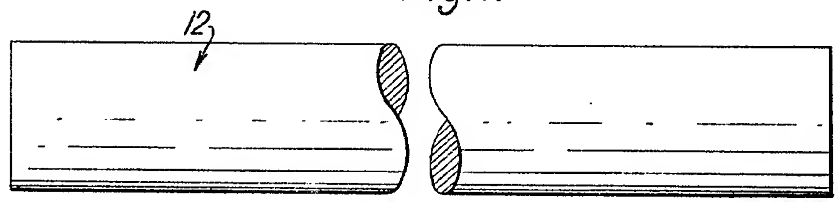

Fig. 2.

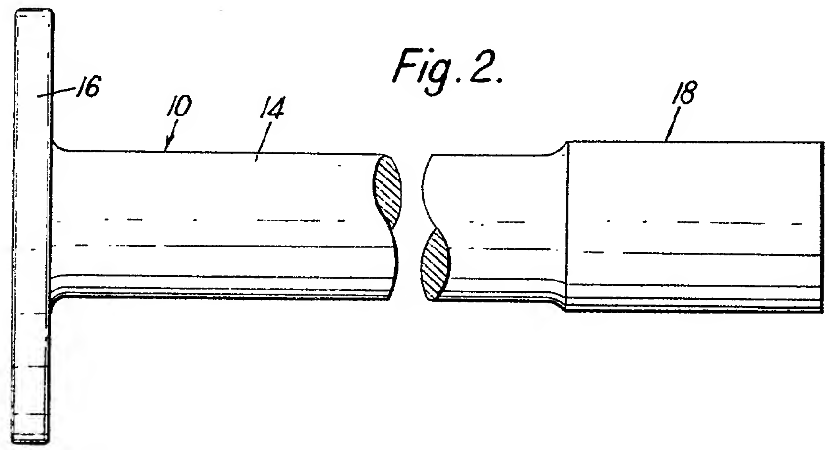

Fig. 3.